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FEEDING DEVELOPMENT: CHINA'S ONGOING SEARCH FOR ENERGY SECURITY

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Mark R. Kendrick

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Thesis Advisor:	Robert E. Looney
Second Reader:	Michael A. Glosny

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FEEDING DEVELOPMENT: CHINA'S ONGOING SEARCH FOR ENERGY SECURITY

Mark R. Kendrick
Lieutenant, United States Navy
BS, Truman State University, 2009

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March 2019**

Approved by: Robert E. Looney
Advisor

Michael A. Glosny
Second Reader

Afshon P. Ostovar
Associate Chair for Research
Department of National Security Affairs

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ABSTRACT

Over the last decade, China has taken significant steps to develop a renewable energy framework in an effort to lessen reliance on coal and its associated health and environmental impacts. This thesis will seek to explain China's domestic and foreign energy-policy approach to dealing with the challenges of maintaining a consistent, stable supply of fuel for its growing economy. This thesis will also examine the implications of China's policy changes for the United States with regard to potential security challenges as well as future cooperation opportunities. China's energy framework over the coming decades is based on three key components. The first is development of new renewable energy generation and transmission capacity. The second is increased natural gas usage. Rather than wait for renewable energy sources to fully replace coal generation, China is turning to natural gas as a stop-gap measure in the short-term to rapidly reduce coal usage and fill some of the generation capacity that renewable sources are as yet unable to. The third component is China's pursuit of new and varied sources of oil as demand continues to grow. Structured as a myriad of bilateral agreements with oil-producing nations, China is conducting energy diplomacy throughout the Middle East and Africa. These three components of a comprehensive energy policy show the path that China is on to achieve its 2030 clean energy goals and become the world leader in clean energy technology.

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I. INTRODUCTION

A. RESEARCH QUESTION AND FINDINGS

As the world's largest consumer and importer of energy,[1] China is in a position that is both uniquely vulnerable, as well as highly influential in the world energy market. As China's economy has grown, so too have its energy needs. According to the International Energy Agency, China's total energy generation capacity grew from less than 300 GW in 2000 to almost 1900 GW in 2017. In addition, the annual average growth of passenger car fuel use was almost 150,000 barrels per day over the same period.[2] As a general principle, countries look for energy sources that best provide for three core needs: economic security, geopolitical security, and environmental security.[3] In pursuit of these needs, China has had to make certain shifts in its energy goals and policies, both domestic and international.

The primary goal of this thesis is to explain China's domestic and foreign energy policy approach to dealing with the challenges of maintaining a consistent, stable supply of fuel for its growing economy. To do so, this thesis will seek to answer the question: What steps has China taken over the last two decades to address the challenge of maintaining consistently high rates of growth fueled by an ever-increasing need for energy security? In addition, this thesis will look at the ways in which China's energy policy has evolved to embrace recent technological innovations like renewable energy in the form of solar, wind, and hydro, as well as shale oil boom extraction techniques like fracking. This thesis will also examine the way in which China's pursuit of oil and natural gas imports has impacted its relationship with producer nations and the larger impact to the global energy market.

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[1] "BP Statistical Review of World Energy 2017" (Centre for Energy Economics Research and Policy, June 2017), https://www.bp.com/content/dam/bp/en/corporate/pdf/energy-economics/statistical-review-2017/bp-statistical-review-of-world-energy-2017-full-report.pdf.

[2] International Energy Agency, "World Energy Outlook 2017: China," International Energy Agency, November 14, 2017, https://www.iea.org/weo/china/.

[3] Edward Hunter Christie et al., "China's Foreign Oil Policy: Genesis, Deployment and Selected Effects," Research Report (FIW Research Reports, 2010), https://www.econstor.eu/handle/10419/121209, 2–3.

The single largest impact to China's energy policy in the last decade has been the acknowledgement that continued reliance on coal is not sustainable for China's development goals. The combined environmental and domestic health impacts of fossil fuel use on this scale is fundamentally incompatible with a growing middle class and the transition away from a heavy manufacturing-based economy into a more developed service-based economy. In order to embrace the transition away from coal, China's central government has implemented certain policies to both rapidly build up renewable energy generation capability, and the associated transmission infrastructure necessary to get power from the sources, to the usage centers on the coast. Beyond just edicts from the center though, China has taken steps to encourage private investment in the renewable energy sector in an effort to promote competition and drive down prices through competition. The largest hurdle to widespread adoption of renewable energy over coal is undeniably cost. While renewable prices have been getting more competitive with coal over recent years, China is still looking at years of infrastructure development and technology improvements before significant coal replacement is viable on a cost basis.

In order to speed this transition along, China is not relying entirely on renewable energy development, but is turning toward natural gas as a means of rapidly phasing out at least a portion of coal usage for a much cleaner-burning source. Widespread adoption of natural gas is not without its own issues unfortunately. China's domestic sources of natural gas are both difficult to extract, and very costly with current technology. This leaves China with the necessity of importing vast amounts of natural gas from all over Asia. Overland via pipelines, and by sea via tanker ships. This need to import over vast distances carries with it significant costs, which place the same hurdles in place of wider adoption. In response, China has taken similar steps to renewable energy adoption by creating market incentives that promote private investment on the local and regional level in an effort to drive costs down through competition. The central issue in trying to replace coal with natural gas is once again that of relative cost to the end-user.

The third main aspect of China's comprehensive energy framework over the next few decades is an emphasis on reliable assess to oil. Given the limited domestic oil supplies that exists in China, the country is almost entirely dependent on imports to meet an ever-

increasing need. This need has resulted in a network of bilateral trade and infrastructure development agreements with oil producing countries led by China's national oil and gas development companies. Over the last decade, China's influence in the Middle East and Africa has drastically grown. With ready offers of financing and infrastructure projects, China has found a means of imbedding its influence within many of the less developed oil producing countries throughout the world. The end result is that China now has access to a wide array of oil suppliers that is largely insulated from supply and price fluctuations within the global market.

B. RESEARCH QUESTION SIGNIFICANCE

In today's world, energy serves as the critical base of economic development, social progress, and the continued growth of modern civilization. In the past decade, China has made significant efforts to reach lasting, mutually beneficial agreements with countries throughout Asia, the Middle East, and Africa, all in pursuit of meeting its rising demand for energy. China is also able to satisfy almost all of its industrial coal requirements with domestic production, but at significant and unsustainable levels of smog and pollution. In recognition of this reality, China has begun to transition away from coal and fossil fuels and develop cost effective and alternative sources of energy. The International Energy Agency defines energy security as the "uninterrupted availability of energy sources at an affordable price."[4] China's energy policies from the 12th and 13th Five Year Plans have made it clear that the central government is not yet confident in either the availability of, or the market price resilience of its energy framework. This has led to a number of sweeping policy efforts both at home and abroad to create a comprehensive energy security plan that is significantly less reliant on coal.

C. LITERATURE REVIEW

There exists a direct correlation between a nation's energy supply and its national security. Xu Xiaojie of the Chinese Academy of Science explained that "energy security is

[4] International Energy Agency, "Energy Security," accessed May 22, 2018, https://www.iea.org/topics/energysecurity/.

national security, and identified crude oil as a strategic commodity that is indispensable for core functions of modern economic systems (and national defense) and cannot be substituted in the short or medium term."[5] In order to feed the rapid growth of its economy and the ever-increasing consumption of energy, China has become increasingly dependent on natural gas and oil imports. Able to supply the majority of its own domestic coal needs, China's pursuit of oil and gas has resulted in a growth of trade relationships with energy exporting countries around the world.[6] Seeking to secure a diverse supply network, China's National Oil Companies have made significant equity investments in more than forty different countries.[7] In doing so, they have also served to create stronger diplomatic ties with potential allies and have begun to create regional energy related forums like the Shanghai Cooperation Organization in order to strengthen ties and smooth negotiations among member nations.[8] This reliance on foreign resources, while effective at meeting current demands, has some clear vulnerabilities that China is seeking to correct.

1. Reliance on Foreign Oil

Despite long-term goals to eventually move away from fossil fuels outlined in the 12th and 13th Five Year Plans, China had already become the world's largest importer of oil by 2013. Forecasts predict that by 2035, China appetite for oil will make up more than half of global consumption growth, and that oil will account for 85% of total Chinese energy consumption.[9] While the current global energy markets largely preclude the need for oil competition among states, China has become more and more dependent on foreign oil imports. This reliance has resulted in a series of bilateral deals and resource extraction agreements with oil producing nations that have ultimately resulted in China assuming a

[5] Zhao Hong, *China and ASEAN: Energy Security, Cooperation and Competition* (ISEAS-Yusof Ishak Institute, 2015): 6.

[6] Wensheng Cao and Christoph Bluth, "Challenges and Countermeasures of China's Energy Security," *Energy Policy* 53 (February 1, 2013): 381–88, https://doi.org/10.1016/j.enpol.2012.10.070.

[7] Kang Wu, "China′s Energy Security: Oil and Gas," *Energy Policy* 73 (October 1, 2014): 4–11, https://doi.org/10.1016/j.enpol.2014.05.040.

[8] Ole Odgaard and Jørgen Delman, "China′s Energy Security and Its Challenges towards 2035," *Energy Policy* 71 (August 1, 2014): 108–114, https://doi.org/10.1016/j.enpol.2014.03.040.

[9] Odgaard and Delman, 108–114.

much more active role in both infrastructure development and joint venture projects all throughout the Middle East and Africa. This increased involvement has strategic implications and raises questions about China's increasing impact in the region especially with regards to other major powers like the United States.[10]

While making significant inroads and investment agreements with oil producers in both South America and Africa, the vast majority of China's oil imports come from the Middle East.[11] When faced with the task of getting all of that oil into the country, there are two primary means of transport. Either by overland pipelines through western China, or by large shipping tankers. Analysts agree that for most of the oil coming from the Middle East and Africa, shipping tankers via water are by far the most cost effective and efficient method to transport, but it the context of energy security and comprehensive national security, this poses an additional level of risk.[12]

2. The Malacca Dilemma

While China has been relatively successful in diversifying the sources of its oil, most of its oil imports are delivered by sea in tankers. Given that most of these suppliers are located in either the Middle East or Africa, most of China's oil imports end up going by tanker ships and subsequently pipelines via the Straits of Malacca, making this area a potential chokepoint if any future enemies sought to inhibit this flow.[13] The United States has kept up a strong fleet presence in these waters for the last two decades in an effort to support local multilateral freedom of navigation and safety of passage agreements through this transit lane. Odgaard and Delman explain that "this is perceived as a realistic security threat by China. On the one hand, Chinese ships travel under a security umbrella provided by the US, on the other hand the U.S. fleet could block China's oil supplies if a conflict arises between China and the US. Terrorism and piracy are also latent threats along this

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[10] Cao and Bluth, "Challenges and Countermeasures of China's Energy Security," 382.

[11] Daojiong Zha and Michal Meidan, "China and the Middle East in a New Energy Landscape" (Chatham House: The Royal Institute of International Affairs, October 2015): 2–3.

[12] Elizabeth Economy and Michael Levi, *By All Means Necessary: How China's Resource Quest Is Changing the World* (OUP USA, 2014): 140–143.

[13] Cao and Bluth, "Challenges and Countermeasures of China's Energy Security," 383.

important sea transport route."[14] In order to limit this strategic vulnerability, China was felt the need to develop a number of different methods for getting its oil from the supplier countries and across Asia.

3. The One Belt, One Road Initiative

In an effort to build stronger economic relationships throughout Asia and limit strategic vulnerabilities like the Malacca Dilemma, Xi Jinping's One Belt, One Road Initiative has sought to secure leases and build ports in the countries of Myanmar, Pakistan, Sri Lanka, and the Maldives. By building these ports, particularly in Pakistan and Myanmar, China is seeking to mitigate the effects of a naval blockade since these two countries are also connected to China via overland pipelines.[15] In the event of a maritime conflict that would likely cut off access to the Straits of Malacca China could concentrate its forward deployed assets within the Indian Ocean to protect tankers and these ports rather than spreading their forces along the entire route back to mainland China.[16]

More than that though, the One Belt, One Road initiative has been a way for China to promote its economic goals and agenda throughout Asia. The 13th FYP lays out objectives to "increase outbound and inbound investment, promote the international use of the renminbi (RMB), and enhance China's role in global economic governance. The Chinese government is seeking to expand its interregional and international trade through the creation of the Beijing-Tianjin-Hebei megaregion and the Yangtze Economic Belt."[17] This increased infrastructure development only strengthens China's ties with its energy producing neighbors and ensures a more stable environment for energy markets.

In addition, China has already made significant inroads in Africa. For years, the Chinese National Oil Companies have pumped billions into resource development and

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[14] Odgaard and Delman, "China′s Energy Security and Its Challenges towards 2035," 108–114.

[15] Economy and Levi, *By All Means Necessary,* 145–147.

[16] Guy C. K. Leung, "China's Energy Security: Perception and Reality," *Energy Policy* 39, no. 3 (March 1, 2011): 1330–37, https://doi.org/10.1016/j.enpol.2010.12.005.

[17] Katherine Koleski, "The 13th Five-Year Plan," Staff Research Report (U.S-China Economic and Security Review Commission, February 14, 2017).

exploitation contracts.[18] In 2015, Chinese President Xi Jinping pledged that China would invest an additional $60 billion in infrastructure and development projects around the continent. Why the additional investment when the oil was already secured? As part of the great build-out, China is eager to maintain relationships with these nations and shift its labor- and energy-intensive industries to Africa to broaden its partnerships beyond energy.[19]

4. Shale-Oil Development

China is "estimated to hold 230 trillion cubic feet (Tcf) to 1,275 Tcf of shale gas reserves, with the International Energy Agency (IEA) calling it the largest in the world. Even if the higher end volumes are exaggerated, it is indisputable that China has significant quantities of shale reserves. Therefore, its development is an attractive proposition."[20] Since Chinese natural gas consumption has far outpaced production and shows no signs of slowing down, the latest government targets call for a doubling of current shale gas production within the next five years.[21] The problem is that it took significant public-private investment and technology development for the United States to reach the point it is currently at. Comparatively, China has just begun to tap this potential resource.

In order to provide incentive and further support shale production, China has created local subsidies and gas pricing reforms, these efforts fail to address the logistical and technological issues. The World Resources Institute noted that "despite the Chinese government's support of shale development, its progress may be constrained by the scarcity of water resources. Competition for water between fracking and other end uses was vividly illustrated in northern Shaanxi province when officials temporarily cut off a city's water

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[18] Sascha Muller-Kraenner, *Energy Security* (Routledge, 2015): 30–36.

[19] Meghan L. O'Sullivan, *Windfall: How the New Energy Abundance Upends Global Politics and Strengthens America's Power* (Simon and Schuster, 2017): 231–252.

[20] International Energy Agency, "China's Power Sector Reforms," accessed May 29, 2018, https://webstore.iea.org/chinas-power-sector-reforms.

[21] "How U.S.-China Cooperation Can Expand Clean Energy Development | World Resources Institute," World Resources Institute, April 25, 2014, http://www.wri.org/blog/2014/04/how-us-china-cooperation-can-expand-clean-energy-development.

supply during a shale drilling test."[22] In order to successfully force the oil out of the fractured bedrock, significant amounts of water must be forced underground. The problem is that the regions that have the most potential for shale oil are also some of the most arid and water deprived. These hurdles present possible points where cooperation and mutual investment between China and the United States could occur.

5. Reliance on Coal

An oddity among major economies, China is still uniquely dependent upon coal as a primary source of power generation. Over the past decade, coal has accounted for over 60% of China's total energy usage compared to less than 20% for the rest of the developed world.[23] According to Odgaard and Delman, "China will also likely contribute more than any other country to the incremental future increase in the global demand for coal based simply on current power generation infrastructure systems. Effectively, China is likely to account for almost half of the global net growth in coal until 2035."[24] The associated pollution and smog that coal usage produces has finally prompted the Chinese government to take action. Last year, according to the BP Energy Review and the International Energy Agency, China has actually begun to see a decline in domestic coal production and consumption.[25] As China's industrial centers begin to face more stringent regulations and shift away from coal power for electricity, we are going to see correlating increases in natural gas from Russia and Kazakhstan as well as new renewable sources like wind, biomass and solar.[26]

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[22] "How U.S.-China Cooperation Can Expand Clean Energy Development | World Resources Institute."

[23] Giulia C. Romano and Jean-Francois Meglio, *China's Energy Security: A Multidimensional Perspective* (Routledge, 2016): 231–250.

[24] Odgaard and Delman, "China's Energy Security and Its Challenges towards 2035," 108–114.

[25] International Energy Agency, "China's Power Sector Reforms"; "BP Statistical Review of World Energy 2017."

[26] Tai Ming Cheung et al., "Understanding China's Plans for Technological, Energy, Industrial, and Defense Development" (U.S-China Economic and Security Review Commission, July 28, 2016): 69–72.

6. Pushing Back against Fossil Fuels and Pollution

In the 13th Five Year Plan (FYP) of the National People's Congress, there is a special emphasis placed on green growth.[27] The 13th FYP puts into writing, the central government's intent to immediately implement significant reforms aimed at addressing China's significant pollution and environmental problems. The means of this reform are the rapid adoption of clean energy sources and a shift away from coal as a means of driving industrial growth and manufacturing. Zhao Hong explains that "environment-related targets account for 10 out of the 25 targets laid out in the 13th FYP, and all 10 are binding targets that must be met by 2020. Targets establish caps for energy use and ambitious goals for city air quality, carbon dioxide intensity, and reduction of soil and water contamination."[28] The implementation for this green energy policy has largely been up to the private sector though. "The Chinese government has opened up select energy subsectors to private enterprises, especially in new technology areas such as wind and solar energy, and encouraged cooperation with international companies ranging from licensing to joint ventures in areas where it has sought outside technology."[29] Scholars have also noted though, that the overarching concern of the central government has been to maintain domestic control of what is becoming viewed as a strategic lifeline of the Chinese economy.[30]

7. A Long-Term Plan

The Chinese government consistently tries to plan for critical resources beyond just the typical five-year cycles. Analysis has shown that the longest commitments in these plans are embodied in the climate planning process, where the Chinese government has committed to the UN Framework Convention on Climate Change to "peaking carbon dioxide emissions around 2030 and making best efforts to peak early," and reducing the

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[27] "The 13th Five-Year Plan for the National Economic and Social Development of the People's Republic of China," accessed May 28, 2018, http://www.gov.cn/xinwen/2016-03/17/content_5054992.htm.

[28] Koleski, "The 13th Five-Year Plan."

[29] Cheung et al., "Understanding China's Plans for Technological, Energy, Industrial, and Defense Development," 159–163.

[30] Hong, *China and ASEAN*, 75–84.

carbon intensity of the economy (carbon dioxide per unit GDP) by 60 to 65% by 2030 from a 2005 baseline.[31] This forward leaning goal follows up on China's 2014–2020 Climate Change Action Plan, which calls for implementing nuclear, renewable, and energy efficiency plans. It also calls for restructuring the Chinese economy away from more energy-intensive industries and toward both greater value-added sectors and the service sector, which is also an overall 13th Five-Year Plan goal.[32]

D. POTENTIAL EXPLANATIONS AND HYPOTHESIS

The primary hypothesis that this thesis will explore is that despite China's desire to move away from traditional fossil fuels and develop cleaner, renewable sources due to rising pollution concerns, the realities of implementation and infrastructure creation will require a long-term plan that relies on traditional carbon-based sources for the foreseeable future. China's pursuit of renewable energy sources is a direct result of a heavy reliance on coal and other hydrocarbon fuels over the past few decades. Under the previous 12th Five Year Plan, the Chinese government had dedicated significant funding and research to clean energy industries, but a combination of weak enforcement policies and a lack of incentives for local governments and industries to make the necessary investments has hampered this desired shift.[33] Another challenge that China's policy makers face is the relative cost of clean energy compared to traditional coal sources. In many cases the government fines on businesses for using coal are still far cheaper than switching to cleaner energy. Another factor is likely the disconnect between local government officials and the desires of the central government. Many at the local level will seek to prioritize a narrower view of economic development and ignore larger issues of environmental protection, thereby mitigating any positive change the policy makers intended.[34] This all translates to

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[31] "'Enhanced Actions on Climate Change,' Submitted by the Government of China to the UN Framework Convention on Climate Change on June 30, 2015.," accessed May 30, 2018, http://www.xinhuanet.com/english/china/2015-06/30/c_134369837.htm.

[32] Cheung et al., "Understanding China's Plans for Technological, Energy, Industrial, and Defense Development," 38–64.

[33] Wu, "China′s Energy Security," 7–9.

[34] Koleski, "The 13th Five-Year Plan."

a number of problems for China's policy makers that need to be remedied for continued adoption of renewable energy to be successful.

China, having witnessed the United States become one of the world's largest oil suppliers in less than a decade, is now seeking to develop its own unconventional gas deposits. As an additional hedge against possible future military blockades or economic downturns that would negatively affect the price or availability of foreign oil, China's large, untapped shale gas deposits offer a means of minimizing dependence on foreign suppliers as well as the possibility of future oil exports. Previously, the cost of tapping these deposits was not profitable when the price of a barrel of oil was down around $40, but now that prices appear to be steady in the $70 range, and the cost of technology has drastically reduced, the threshold for shale oil profitability is now well within China's reach.

E. RESEARCH DESIGN

The goal of this thesis is to explain China's energy policy approach to dealing with the challenges of developing a cleaner, cheaper, and growing supply of energy for its economy. Using an explanatory, qualitative case study methodology, this thesis will look at three primary energy sectors within China's comprehensive energy framework: 1) renewable energy sources and development, 2) domestic fossil fuels including natural gas, and shale gas development, and 3) foreign sources of oil and natural gas and the means by which China secures these sources. Due to the unique nature of China's role as a global economic power and the largest energy consumer in the world, a case study method examining multiple energy sectors is appropriate as the only other viable comparison is the United States which has its own, quite different set of goals for future energy security.

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II. CHINA'S TRANSITION TO A FULLY RENEWABLE ENERGY FRAMEWORK

Over the last decade, China has rapidly become the world's leading investor in and developer of wind and solar energy technology. From the period of 2010 to 2015 during the 12th Five-Year Plan, China's commitment to developing renewable energy sources really began to catch momentum. With an outpouring of capital investment that dwarfed both that of the United States and the European Union combined, China accounted for more than 40% of all new clean energy infrastructure development around the world.[35] In order to facilitate this rapid transformation of its energy sector, China has had to make some significant changes to not only its national energy markets, but also to the regulatory policies that promote renewable energy over coal. To put this shift in monetary terms, in 2012, China spent $52 billion on renewable energy development,[36] and by 2020, that numbers is expected to climb to more than $360 billion.[37] The main question this chapter will seek to answer then, is what domestic energy policy changes has China made over the last decade in order to bring about this transition to low-carbon energy, and what challenges have hindered this progress? In order to explore this shift, there will be three main areas of focus. The first part will examine the reasons why China is so focused on developing renewable energy and the milestones that it hopes to meet. The second will look at Chinese central government institutional arrangements, energy market regulations, and infrastructure development related to renewable energy. The final part will look at the difficulties China has faced in developing a clean energy market, particularly with regards to the effects of renewable energy curtailment. In reviewing China's policy decisions over the past decade, and with a focus on the central policy changes of 2015 specifically, it

[35] Wei Shen and Lei Xie, "The Political Economy for Low-Carbon Energy Transition in China: Towards a New Policy Paradigm?," *New Political Economy* 23, no. 4 (July 4, 2016): 407–21, https://doi.org/10.1080/13563467.2017.1371122.

[36] Jack Perkowski, "China Leads The World In Renewable Energy Investment," Forbes, accessed February 28, 2019, https://www.forbes.com/sites/jackperkowski/2012/07/27/china-leads-the-world-in-renewable-energy-investment/.

[37] Michael Forsythe, "China Aims to Spend at Least $360 Billion on Renewable Energy by 2020," *The New York Times*, August 7, 2018, sec. World, https://www.nytimes.com/2017/01/05/world/asia/china-renewable-energy-investment.html.

becomes clear that there is a strong drive in the central government to push clean, renewable energy as a necessary shift away from coal. In documents published by China's National Energy Administration, the goal has been outlined to increase the share of national renewable energy from 6% in 2014 to 15% by 2020.[38] While initial steps have been promising, continued improvement on the national generation and delivery framework is required. One of the largest challenges to wider adoption of renewable energy is the relative cost compared to coal, an issue that China has been working to remedy.

A. CHINA'S GOALS FOR RENEWABLE ENERGY

When examining China's push for renewable energy over the last decade, it is first necessary to determine what the country hope to achieve, and then determine the reasons for this concerted national effort. Renewable energy is power that is generated from the harnessing of naturally recurring sources like solar, wind, geothermal, or tides. These sources are considered renewable because in general terms, they are capable of providing a theoretically inexhaustible supply of energy to meet our needs.[39] The difference between renewables and traditional fossil fuels like coal or oil is that their global supply is ultimately limited to what currently exists and cannot be restored. "Today, these renewables are most often referred to in terms of their technological applications, among the most common being wind turbines, solar photovoltaic (PV) panels, tidal barrages, and biofuels."[40] In China's 13th Five Year Plan (2016-2020), the National Energy Administration adopted certain targets and goals for renewable energy development. Some of these key objectives are:

- Increase share of non-fossil energy in total primary energy consumption to 15% by 2020 and to 20% by 2030.
- Increase installed renewable power capacity to 680 GW by 2020.

[38] "The 13th Five-Year Plan for the National Economic and Social Development of the People's Republic of China."

[39] Christopher M. Dent, "China's Renewable Energy Development: Policy, Industry and Business Perspectives," *Asia Pacific Business Review* 21, no. 1 (January 2, 2015): 26–43, https://doi.org/10.1080/13602381.2014.939892.

[40] Dent, 26–43.

- Resolve renewable power curtailment issue problem.
- Increase installed wind capacity to 210 GW.
- Promote offshore wind and ocean power development.
- Lead renewable energy technology innovation.
- Further support development of the renewable energy industry in China and decrease reliance on foreign companies in the domain.[41]

For this thesis, the focus will be on China's efforts to deal with the first three points on this list: increasing non-fossil energy as a percentage of total, efforts to increase renewable capacity by 2020, and solutions to the issue of renewable energy curtailment on the national grid. The first of these issues can be dealt with through policy and market regulation changes, while the second and third points will require a greater emphasis on infrastructure investment and development at both a national and local level.

B. WHY TRANSITION TO RENEWABLE ENERGY, AND WHY NOW?

Over the last three decades, China's impressive, sustained growth rate has been enabled largely by the consumption of fossil fuels like coal. From 2000 to 2013, China's annual coal consumption grew from 1.36 billion tons per year to 4.24 billion tons, an annual growth rate of more than 12%.[42] This focus on rapid growth and the energy needed to power it has come at both an environmental and a public health cost. "The government's ambitious strategy for expanding coal-power capacity has locked the country into a high emissions trajectory for decades to come, unless both clean coal and carbon capture and storage technologies make considerable advances in the future."[43] Perhaps most telling is that the China Council for International Cooperation on Environment and Development released a report in 2012 that placed the health toll of high pollution levels at almost 300 deaths per million in 2000. This rate was forecasted to further increase to almost 900 deaths

[41] "The 13th Five-Year Plan for the National Economic and Social Development of the People's Republic of China."

[42] Barry L. Johnson and Maureen Y. Lichtveld, *Environmental Policy and Public Health* (CRC Press, 2017).

[43] Dent, "China's Renewable Energy Development," 26–43.

per million by the year 2030 if these pollution trends continued unabated.[44] Christopher Dent has noted that "many parts of China are also highly vulnerable to the climate change risks of extreme weather and rising sea levels. The nation's burgeoning middle class is correspondingly becoming more politically vocal about quality of life issues, such as pollution abatement."[45] Based on the consistent smog layer covering many of China's major urban centers and the rising incidents of asthma and other health issues, it becomes clear that the past levels of reliance on fossil fuels is not sustainable, and that large-scale transition to renewable energy is going to be essential to China's continued growth and public health over the long term.[46]

In 2017, renewable energy generation capacity accounted for over 36% of China's national energy infrastructure, but only made up 26% of nation-wide actual power usage. This represents a significant difficulty in transmitting energy from one part of the country to another.[47] Despite this issue, 36% is still far more than the 18% of total generation capacity that the United States currently has.[48] According to a report issued by China's National Energy Administration, *Energy Production and Consumption Revolution Strategy 2016–2030*, by 2030, the goal is to have at least half of total power generation capability come from renewable sources.[49] China's goal is that the renewable energy infrastructure growth will shift from no longer just meeting new electricity needs, but will begin replacing existing electricity generation capacity that has historically been met by fossil fuel sources.

An additional motivating factor behind China's push for a greater percentage of renewable power sources is the need for energy security. In an effort to minimize risks

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[44] Qi Ye and Lu Jiaqi, "The End of Coal-Fired Growth in China" (Brookings Institute, August 4, 2016), https://www.brookings.edu/blog/up-front/2016/08/04/the-end-of-coal-fired-growth-in-china/.

[45] Dent, "China's Renewable Energy Development," 26–43.

[46] Dong Wenjuan and Qi Ye, "Utility of Renewable Energy in China's Low-Carbon Transition" (Brookings Institute, May 18, 2018), https://www.brookings.edu/2018/05/18/utility-of-renewable-energy-in-chinas-low-carbon-transition/.

[47] Wenjuan and Ye.

[48] David Morris, "Renewable Energy Surges to 18% of U.S. Power Mix," Fortune, accessed January 15, 2019, http://fortune.com/2018/02/18/renewable-energy-us-power-mix/.

[49] Wenjuan and Ye, "Utility of Renewable Energy in China's Low-Carbon Transition."

faced by uncertain future supply, and uncertain prices in the global market, China is seeking alternatives. In terms of domestic energy supply, China's traditional fossil fuel deposits have never been sufficient to supply demand, and have been steadily depleted over the past two decades due to rapidly increasing need. Christopher Dent explains that China "is the world's second largest oil and coal importer, and the fourth largest importer of liquefied natural gas. Concerning nuclear, the country possesses only an estimated 1% of global uranium reserves, currently maintains a 65% import dependency on the mineral and has seen its uranium import levels triple from 2009 to 2011."[50] Many in China see renewable energy sources as the answer to potential future energy import security concerns. While their very nature sometimes makes solar and wind power generation subject to the elements, they also have the advantage over fossil fuels of being locally produced sources of energy, thus minimizing dependence on outside suppliers for future supply needs.

C. CHINA'S UNIQUE DEVELOPMENT

It has been historically shown that "peak coal," or the point in time where coal production and consumption reaches its maximum for a developing country, is often a key milestone in the development process of Western economies. Ye Qi and Jiaqi Lu argue that "in transitioning to post-coal growth, China is following the path of now-affluent industrial economies: coal consumption growing with per-capita income before peaking and declining."[51] The best examples of this transition model are Great Britain and the United States. Both nations progressed along similar developmental lines, gradually transitioning away from coal, and into oil and natural gas, with the eventual start of the shift towards renewable sources. Having experienced the negative environmental and social impacts of this reliance, China is taking steps to consciously end its early stage reliance on coal-powered growth and limit the mid-stage oil and natural gas period. China is working to boot-strap its energy infrastructure directly into the post-industrial clean energy stage.[52] The difference when comparing China to Great Britain and the United States, is that the

[50] Dent, "China's Renewable Energy Development," 26–43.

[51] Ye and Jiaqi, "The End of Coal-Fired Growth in China."

[52] Ye and Jiaqi.

timing of China's peak coal consumption (roughly 2013)[53] occurred much earlier in the country's development cycle. Taking into account China's relatively late industrialization and over-reliance on coal energy production, its intentional peak coal shift towards clean, renewable energy demonstrates a clear understanding of the environmental impact that carbon based forms of energy have on a country.

D. EARLY EFFORTS AT REFORM

Since 1985, China's energy regulations have experienced more than a few shifts in strategic direction. The first round of energy policy reforms in 1985 was designed with the intent to encourage both new open market companies and local government interests to buy into new power generation infrastructure. This new surge of investment had the effect of starting the transition of power generation and transmission infrastructure development away from the central government and into the local and regional control.[54] Zhang et al. explain these early changes and the formation of the new energy framework:

> While the reforms in the late 1990s separated government functions from enterprise management, the 2002 reforms witnessed China's power sector move from a single, vertically integrated utility to two grid companies, namely the State Grid Corporation of China (SGCC) covering most of the country, and the China Southern Grid Corporation (CSGC) covering five southern provinces, five large generating companies and a large number of other companies. In addition, five regional grid companies were created as subsidiaries of the SGCC.[55]

These changes were only the precursor to the reforms of 2015 and the broad policy goals of the 13th Five Year Plan.

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[53] "IEEFA Update: China Is Now Three Years Past Peak Coal," *Institute for Energy Economics & Financial Analysis* (blog), February 28, 2017, http://ieefa.org/ieefa-update-china-now-three-years-past-peak-coal/.

[54] Sufang Zhang, Philip Andrews-Speed, and Sitao Li, "To What Extent Will China's Ongoing Electricity Market Reforms Assist the Integration of Renewable Energy?," *Energy Policy* 114 (March 1, 2018): 165–172, https://doi.org/10.1016/j.enpol.2017.12.002.

[55] Zhang, Andrews-Speed, and Li.

E. 2015 NATIONAL ENERGY ADMINISTRATION REFORMS

The central challenge China will be facing in its power generation system over the next decade is how to ensure that renewable sources are appropriately prioritized over coal-fired power and are not left behind due to higher prices for end-users. The 13th FYP has brought about a new focus for the development of the Chinese energy sector. Previously, stimulus and funding was geared toward the continued buildup of new power generating capacity. Now though, focus has shifted towards methods of streamlining operation of the national energy grid and ensuring that generation regions in the interior are properly linked to the usage regions on the coast.[56] Since 2015, the Chinese National Energy Administration (NEA) has directed a series of reforms with the following goals:

- Promote more efficient operation of power distribution, and create a market-based mechanism to determine volumes and pricing for wholesale markets.[57]

- Promote grid-integration of wind and solar, by launching Renewable Portfolio Standards (RPS), requiring individual province-level utilities (grid operators) to meet targets for lower-carbon generation.

- Another policy, the "Minimum Guaranteed Dispatch of Renewables," seeks to address curtailment issues by instituting minimum hours for utilization of wind and solar assets in various provinces.

- In order to discourage over-investment in new wind and solar capacity in provinces plagued with severe curtailment, the NEA also announced a new investment risk metric system to guide provincial regulators and project developers[58]

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[56] Yiyi Zhou and Sophie Lu, "Chinas Renewable Curtailment and Coal Assets Risk Map," Research Findings (Bloomberg New Energy Finance, October 25, 2017): 2–13, https://data.bloomberglp.com/bnef/sites/14/2017/10/Chinas-Renewable-Curtailment-and-Coal-Assets-Risk-Map-FINAL_2.pdf.

[57] Zhou and Lu, 2–19.

[58] Zhou and Lu, 2–19.

The primary impetus for these changes was the realization that energy needs were continuing to increase to the point that additional generation capability would be needed. When faced with the choice to create more reliance on coal, or to begin the development of cleaner options, China's central government began the transition in earnest. Prior to these reforms, much of the responsibility for determining plant production dispatch and generation was delegated to the local governments in the provinces. This ultimately meant that local power production regulators were responsible for determining wholesale prices for which power plants were allowed to sell their energy to the regional grid, and the retail prices at which those grid companies were able to sell to the customer.[59] The end result for the energy market in many provinces was one in which all energy generated was sold to the grid companies equally and then on to consumers at the same price, regardless of the cost to actually produce it.

After the reforms of 2015, the wholesale power market was essentially split in two, with the power generated by wind, solar, nuclear, and hydro continuing to be dispatched and priced by regulators, while the rest of the majority of the market, supplied by coal-generation, to be traded at market demand prices.[60] Regulators were now required to lower guaranteed generation quotas for existing coal power plants by 20% beginning in 2017 with further reductions planned for each following year. In addition, all new coal power plants that receive NEA approval for development after 2015, will not be allocated any planned generation allotment. Instead, they must compete in markets to contract for 100% of their generation dispatch.[61] Essentially this was the NEA's way of removing government protection for the coal power generators and incentivizing all new energy production to be in renewable sectors. While these changes may have found a way to promote the growth of renewable energy within the national marketplace, the underlying infrastructure for its delivery to consumers is still lacking, and with so many new clean energy projects coming online, there are more and more issues relating to "curtailment" of this new energy supply.

[59] Zhou and Lu, 2–19.

[60] Zhou and Lu, 2–19.

[61] Zhou and Lu, 2–19.

F. CHINESE ENERGY INSTITUTIONS AND DECISION MAKING PROCESS DIFFICULTIES

China's approach to renewable energy development can be divided into two main categories. The first category is regulatory mandates which serve to establish national guidelines to stipulate that both investors and private firms conform to the vision of the central government.[62] The second is the traditional form of Chinese market guidance and direct state subsidies. With regard to the first method, these broad scope policies are those handed down by the NEA, or by the central government in the FYPs. The problem that China is still facing in its energy markets is that while policy changes may be dictated at the national level, they need to be carried out at the regional and local level. While this disparity should come as no surprise to one familiar with China's history, it still remains a problem regardless of how far the center has relinquished control to market forces. A sub-bureau of the NEA, the Renewable Energy Department has been given responsibility for the oversight of all public and private investment regarding new generation capacity development and planning. As a more refined vision than that released with the Five Year Plans, the NEA established specific targets for new development each year. Once these targets are made public, then the regional and local leaders can work with investors to determine the direction their efforts should take.[63] This becomes an issue when the NEA adjusts macro policy for the country, but when it comes to regional development and pricing of energy, the local officials have almost complete discretion.

The divide between national and local government is also apparent in the emphasis placed on tariffs and local incentives. New investments in solar and wind development serve to deliver substantial economic benefits and taxation opportunities for local governments. For regional officials, the risk of losing out on potential economic growth, local employment opportunities, and tax revenues, all of which serve as important metrics when determining promotion potential, provides significant incentive to work with private developers and financial institutions.[64] A central theme of the last decade when speaking

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[62] Dent, "China's Renewable Energy Development," 26–43.

[63] Shen and Xie, "The Political Economy for Low-Carbon Energy Transition in China," 407–421.

[64] Shen and Xie, 407–421.

about regional energy development is the question of how to maintain an enthusiasm among local officers for continued renewable investment while at the same time, properly focusing their efforts in directions that are actually beneficial to the national grid objectives. In an effort to get around the limitations of central government oversight, local and regional officers have found creative ways to funnel investment money into a number of smaller, seemingly unrelated projects that fly under the radar in the way that a larger, and often more beneficial project wouldn't.[65] This disconnect between central planning and local government efforts is highlighted in the laissez-faire approach that many officers take towards environmental regulations and land use.[66] It also tends to further exacerbate the issues of overcapacity on the national grid and the difficulty of getting power from generation to end-users.

The second approach that China takes in developing renewable energy capacity is a combination of two different financial policies that based on China's traditional form of market guidance. The first part can be described as direct financial support in the form of state subsidies, grants, loans, and capital investment in renewable energy infrastructure. The second part is a set of market-based instruments like price setting mechanisms to provide a variety of different tax incentives, feed-in-tariff systems, and competitive permit bidding.[67] While these systems are in their infancy now, and their effectiveness has not had the chance to be fully observed yet, they have the ability to shift China's energy sector into a more market led system that would encourage the creation of inter-regional networks that would better handle the issues of curtailment that are currently overshadowing China's renewable progress thus far.

G. CHALLENGES TO RENEWABLE DEVELOPMENT

China faces two primary challenges to its 2030 renewable energy goal. The first is possibly the most straightforward of all public policy issues: cost. The single largest hurdle in the path of increased renewable energy adoption is the difference in relative cost between

[65] Shen and Xie, 407–421.

[66] Shen and Xie, 407–421.

[67] Dent, "China's Renewable Energy Development," 26–43.

current renewable technologies like solar and wind power generation and coal. As with the adoption of any new technology, the initial development years are far more expensive simply because of the inherent initial start-up costs. While China already has a well-developed infrastructure in place to facilitate coal power, solar and wind power require additional power storage and transmission systems to get the capacity from generation sites to the usage locations in urban areas along the coast. This cost disparity has actually been decreasing in recent years as renewable technology has improved, and infrastructure investment, both public and private has contributed to more efficient generation practices and associated cost reductions.

While China's progress with developing a renewable energy infrastructure has been quite rapid, it is not without its issues. The second largest challenge in China's continued development of renewable energy is the issue of curtailment. According to the National Renewable Energy Laboratory, curtailment is "a reduction in the output of a generator from what it could otherwise produce given available resources, typically on an involuntary basis. Curtailment of generation has been a normal occurrence since the beginning of the electric power industry."[68] The problem China has is that wind, solar, and hydro generation is at a disadvantage because China's power market is currently designed in a way that does not allow for economically rational dispatch – i.e., dispatching generated power based on the marginal cost of those plants. In a system of rational dispatch, zero-cost wind, solar, and hydro power would be prioritized ahead of other carbon burning forms of generation.[69]

The most common form of curtailment is operator-induced. This issue is often a result of insufficient energy transmission infrastructure that results in a congestion in the system, or simply a lack of access to the transmission grid.[70] The reason why curtailment happens within these new solar and wind systems is because there is often excess generation during low load periods, and there is no means of storing that energy for later

[68] Lori Bird, Jaquelin Cochran, and Xi Wang, "Wind and Solar Energy Curtailment: Experience and Practices in the United States" (National Renewable Energy Laboratory, March 1, 2014): 4–9, https://doi.org/10.2172/1126842.

[69] Zhou and Lu, "Chinas Renewable Curtailment and Coal Assets Risk Map," 38–51.

[70] Zhang, Andrews-Speed, and Li, "To What Extent Will China's Ongoing Electricity Market Reforms Assist the Integration of Renewable Energy?" 2–4.

high-load times. In addition, the lack of an integrated national power market with the ability to transmit power between regions and local markets prohibits these producers with excess generating capability from selling it to other regions with high demand.[71] Such a framework would facilitate renewable energy integration with the existing conventional power systems. It would also open the possibility for different types of renewable energy to compensate for each other at different times throughout of the day. For example, solar power is naturally more prevalent during the day, while wind power would be able to take over at night.[72] This interconnectedness would allow optimal use of surplus power during peak times and seasons and reduce the need for excess storage and back-up systems.

This over-generation and under-utilization is a result of the significant geographical mismatch between the regions of the country suitable for generating energy, and the consumption centers that require it. Most of the country's urban population and industry is located along the coast, while "over 70% of China's large-scale wind and solar projects have been installed in the resource-rich northern regions featuring low electricity demand and low export capacity."[73] Adding to this disparity, is the fact that these same regions which are ideal for renewable energy development are also the same regions which are most abundant in coal. This highlights one of the problems that China is still dealing with. Namely, that the means of transporting this surplus energy from the generation points to the urban centers of consumption are not in place yet. "As of 2016, eight UHV DC lines with a total length of 11,900km were in operation. Some 16 UHV DC lines are planned to be brought online by 2020. However, less than half of these lines are designated to transmit renewable electricity."[74]

While China's growth of renewable energy production over the last decade has been impressive, there are still a few elements that pose a challenge to the realization of a full clean energy transition. Key among these issues is the underlying nature of the existing

[71] Zhang, Andrews-Speed, and Li, 3–5.

[72] Zhang, Andrews-Speed, and Li, 3–5.

[73] Zhou and Lu, "Chinas Renewable Curtailment and Coal Assets Risk Map," 38–51

[74] Zhou and Lu, 38–51.

set of institutions and regulations that govern the power sector with their entrenched administrative practices and planning.[75] While China's reforms over the last few years have implemented specific market mechanisms aimed at incentivizing renewable energy integration, there are a number of policy changes that still need to be made. Specifically, steps need to be taken to continue state funded subsidies for renewable energy. Currently there is a 100billion RMB subsidy gap for existing wind and solar projects.[76] For continued development to take place, these incentives need to be funded. In addition, the market reforms begun in 2015 need to be continued to their next logical step. This means the further development of regional spot markets for price fluctuations, and auxiliary service markets to better help allocate resources and deal with overproduction curtailment.[77]

H. CONCLUSIONS

China's push to transition from a largely coal-based power generation system over the last decade has been largely driven by the acknowledgement that continued fossil fuel usage will contribute to an ongoing health and environmental crisis for the country. This transition has not been simple, and still has a long ways to go in order to reach the stated replacement goals of 2030. Based on central government policy directives, market regulations, and direct investment incentives, renewable energy generation capacity has rapidly spread through the country. This widespread adoption hasn't been without its difficulties though. The cost of implementing these new system has naturally resulted in higher associated costs with renewable power relative to coal, but as the infrastructure systems become more established throughout the country, these costs have come down. Soon these upgraded transmission systems will solve many of the issues of curtailment and coal power can continue phasing out.

The Chinese government consistently tries to plan for critical resources beyond just the typical five-year cycles. Analysis has shown that the longest commitments in these

[75] Zhang, Andrews-Speed, and Li, "To What Extent Will China's Ongoing Electricity Market Reforms Assist the Integration of Renewable Energy?" 2–6.

[76] Wenjuan and Ye, "Utility of Renewable Energy in China's Low-Carbon Transition."

[77] Wenjuan and Ye.

plans are embodied in the climate planning process, where the Chinese government has committed to the UN Framework Convention on Climate Change to "peaking carbon dioxide emissions around 2030 and making best efforts to peak early," and reducing the carbon intensity of the economy (carbon dioxide per unit GDP) by 60 to 65% by 2030 from a 2005 baseline.[78] This forward leaning goal follows up on China's 2014–2020 Climate Change Action Plan, which calls for implementing nuclear, renewable, and energy efficiency plans. It also calls for restructuring the Chinese economy away from more energy-intensive industries and toward both greater value-added sectors and the service sector, which is also an overall 13th Five-Year Plan goal.[79] It remains to be seen if China's efforts towards renewable energy integration and replacement will continue growing, but it certainly looks like there is a willing to take the first incremental steps in that direction.

[78] "'Enhanced Actions on Climate Change,' Submitted by the Government of China to the UN Framework Convention on Climate Change on June 30, 2015."

[79] Cheung et al., "Understanding China's Plans for Technological, Energy, Industrial, and Defense Development," 38–64.

III. NATURAL GAS: A STOP-GAP MEASURE

In pursuit of a reliable, secure national energy infrastructure, China's goals of completely renewable energy are both ambitious and a long ways off. While there is no doubt that sustainable, renewable energy is the long-term solution to China's reliance on carbon dioxide producing energy sources, and the subsequent environmental issues, there is still a ways to go until that goal becomes a reality. In the meantime, China must find other solutions to meet its growing energy needs. One of the primary ways it is doing so is to dramatically increase both the production and usage of natural gas. As the development of renewable sources ramps up, China and many other countries, are turning towards natural gas as the means of covering the gaps in production that limited solar or wind infrastructure still have. Of particular importance to China is the fact that natural gas is widely regarded as the cleanest fossil fuel, and produces less than half of the carbon emissions of coal when used.[80] Dong et al. explains that "currently, China's natural gas consumption accounts for only 6.8% of the total primary energy consumption and natural gas industry faces many institutional obstacles. The acceleration of natural gas market-oriented reform has become a common focus for the Chinese government, the natural gas industry and academia."[81]

The main focus of this chapter is the growth of natural gas as a share of China's total energy portfolio and the evolution of energy regulation policy necessary to continue the upward trend. The first of three sections will examine the state of natural gas as a portion of China's total energy framework. The second part will explore the challenges that China has been encountering in the effort to increase domestic production. The last part of this chapter will address the current structure of China's natural gas industry, and the reform process that still needs to happen in order to make it a viable replacement for coal. My central conclusion is that in order for China's domestic natural gas market to effectively

[80] "How Much Carbon Dioxide Is Produced When Different Fuels Are Burned? - FAQ - U.S. Energy Information Administration (EIA)," n.d., https://www.eia.gov/tools/faqs/faq.php?id=73&t=11.

[81] Xiucheng Dong et al., "The Reform of the Natural Gas Industry in the PR of China," *Renewable and Sustainable Energy Reviews* 73 (June 1, 2017): 582–93, https://doi.org/10.1016/j.rser.2017.01.157.

supplant its reliance on coal, there first needs to be a degree of both market opening, and pricing policy shifts within the current system. This chapter concludes that while China has significant potential reserves of natural gas that surpass even those held by the United States, it faces a few significant limitations in actually bringing these resources to the national power network in a way that is both affordable and feasible for coal replacement. There are two main reasons for this. The first is the location and viability of these natural gas reserves. Unlike the U.S., China's supply of recoverable shale gas are located in remote, mountainous regions where access to the necessary resources and infrastructure make retrieval difficult and costly. The second reason is that coal is so abundant and cheap in China that there is a significant price disparity that is hampering the adoption of domestic natural gas as a viable replacement. If China was able to implement policy to open up competition in its natural gas supply market to incentivize infrastructure development and cost reductions, it would go a long way to reaching its goal of 300 billion cu. meters of domestic production in 2030.[82]

A. CURRENT SUPPLY OF NATURAL GAS AND ROLE WITHIN CHINA'S ENERGY FRAMEWORK

Until China can fully realize its dreams of sustainable, renewable energy to both provide economic and national security with green sources like wind and solar, there needs to be a means of decreasing reliance on coal while still meeting growing industrial and domestic energy needs. Natural gas is the primary candidate to fill in until renewable sources dominate the market. Having pledged to reach peak national carbon emissions under the Paris Climate Accords by 2030, the Chinese government has resolved to increase the use of natural gas within the national energy grid to over 10% by 2020.[83] To reach this goal, China has had to increase investment and development of domestic sources of natural gas as well as create new import contracts with gas producing countries throughout the

[82] Irina Slav, "Here's Why China Won't Have a Shale Boom," Business Insider, accessed January 14, 2019, https://www.businessinsider.com/heres-why-china-wont-have-a-shale-boom-2018-4.

[83] Cao and Bluth, "Challenges and Countermeasures of China's Energy Security," 381–388.

region. By 2020, China expects to import over 220 billion cubic meters of natural gas annually from Central Asia, Russia, Australia, Malaysia, and Indonesia collectively.[84]

In 2016, the country's gas consumption was recorded at 200 billion cu. meters, which is well below the predicted available supply by 2020, but difficulties began to arise when that consumption was paired with plans to replace coal with natural gas in industrial production and power plants throughout the country.[85] When these substitutions are factored in, predicted consumption raises to between 450 billion cu. meters and 500 billion cu. meters by 2020.[86] "According to British energy giant BP, global natural gas usage will surpass that of coal by 2035, and China will outstrip the European Union and Russia to become the second-largest consumer of the fuel behind the U.S."[87] This means that over the next decade, China needs to either continue increasing domestic natural gas production to meet the rising demands, or increase its rate of import. The likely solution will be a combination of the two as natural gas growth in the country has been slower than expected for a number of different reasons.

B. DOMESTIC PRODUCTION CHALLENGES

In the past eight years, shale gas exploration and development has been slowly increasing in China. Though still lagging far behind the annual output of both the United States and Canada, China has now become the third largest producer of shale gas in the world with proven reserves of over 27 trillion cubic meters.[88] Based mostly within the Sichuan Basin of southwest China, the Fuling field accounts for almost 70% of China's

[84] Yue Qin et al., "Challenges of Using Natural Gas as a Carbon Mitigation Option in China," *Energy Policy* 117 (June 1, 2018): 457–62, https://doi.org/10.1016/j.enpol.2018.03.004.

[85] International Energy Agency, "World Energy Outlook 2017: China."

[86] "China Triples Down on Natural Gas to Hit Climate Goals," Nikkei Asian Review, accessed January 14, 2019, https://asia.nikkei.com/Economy/China-triples-down-on-natural-gas-to-hit-climate-goals.

[87] "China Triples Down on Natural Gas to Hit Climate Goals."

[88] Dazhong Dong et al., "Breakthrough and Prospect of Shale Gas Exploration and Development in China," *Natural Gas Industry B* 3, no. 1 (January 1, 2016): 12–26, https://doi.org/10.1016/j.ngib.2016.02.002.

total natural gas production.[89] The primary difficulty China faces in creating the infrastructure to extract natural gas is that many of China's deposits are located in regions that are both mountainous and far removed from existing facilities and resources. Unlike the shale deposits that have fueled the boom in the United States in recent years, China's deposits are located much deeper, requiring additional resources and technologies to make retrieval possible, along with the additional associated costs. This does not mean that production has stalled, only that development has not been as fast as the National Energy Agency initially predicted back in 2010. Irina Slav notes that "because of the geological peculiarities of its shale deposits, local energy companies have developed proprietary fracking methods specifically targeting the local gas-bearing rocks. They have also significantly cut their drilling costs. Compared with 2010, exploration well costs are down 40 %."[90]

The other primary difficulty associated with shale gas development is the amount of water required. For both fracking and drilling operations, there is a significant amount of water that is required to be pumped into the ground in order to force the gas to the surface. Afterwards this wastewater has to be disposed of, and finding an economically viable means of doing so is a key challenge. The International Energy Agency has estimated that the shale gas cost in water usage is more than 200 times that of conventional gas.[91] This has been a subject of much debate within the United States, especially in places like Texas where excessive water usage at the local level can over-stress limited resources and have negative impacts on the environment.[92] Considering the water scarcity in some of China's more remote regions, the cost and impact of large scale fracking and extraction efforts poses a significant hurdle. "Per capita renewable internal freshwater resources amount to only a third of the world average while about 400 of 660 cities in China suffer

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[89] Meiyu Guo et al., "Prospects for Shale Gas Production in China: Implications for Water Demand," *Renewable and Sustainable Energy Reviews* 66 (December 1, 2016): 742–750, https://doi.org/10.1016/j.rser.2016.08.026.

[90] Slav, "Here's Why China Won't Have a Shale Boom."

[91] Guo et al., "Prospects for Shale Gas Production in China," 742–750.

[92] Nathaniel R. Warner et al., "Impacts of Shale Gas Wastewater Disposal on Water Quality in Western Pennsylvania," *Environmental Science & Technology* 47, no. 20 (October 15, 2013): 49–57, https://doi.org/10.1021/es402165b.

from water shortages, close to 50% of Chinese rivers are severely polluted, and availability of safe drinking water is inadequate to meet the needs of 300 million rural people."[93] This has led some to conclude that the main impediment to China's shale-gas development is the availability and access to sufficient water sources.[94] Some studies, both private and government funded have proposed that the availability of an abundant water supply is a smaller concern, and that regulators should instead focus on the environmental impact of wastewater discharge.[95] This could lead to significant negative environmental impacts as large scale drilling efforts ramp up to meet demand throughout the country.

C. CHINA'S NATURAL GAS INDUSTRY STRUCTURE AND REFORMS

Until 2013, three of China's national oil companies had almost complete control over all natural gas production facilities and the existing pipeline infrastructure. Considering the economic principles inherent in limited monopolies, this resulted in a market that was largely uncompetitive and had few if any incentives for these companies to invest in more efficient technology or means of production.[96] Historically, China's natural gas pricing has been strictly regulated with the goal of protecting consumers, leading to a lack of production incentive and frequent shortages.[97] Beginning in 2013 though, China carried out a number of natural gas pricing reforms with the aim of crafting a more market-based production and supply mechanism. Prior to 2013, the volume of imported natural gas that China was importing had rapidly increasing after the completion of pipeline terminals from Central Asia. "With regulated domestic price at low levels, importers of natural gas were losing money as the contract prices for China's imported natural gas were higher than the regulated prices. The old pricing approach also failed to provide incentives for an expansion of domestic natural gas supply, both conventional and

[93] Guo et al., "Prospects for Shale Gas Production in China," 742–750.

[94] Guo et al., 742–750.

[95] Guo et al., 742–750.

[96] Sergey Paltsev and Danwei Zhang, "Natural Gas Pricing Reform in China: Getting Closer to a Market System?," *Energy Policy* 86 (November 1, 2015): 43–56, https://doi.org/10.1016/j.enpol.2015.06.027.

[97] Paltsev and Zhang, 43–56.

unconventional"[98] Considering that China had also begun efforts to push natural gas as the better replacement for coal, this created an ever growing gap between demand and what could be produced domestically.

Under China's National Energy Agency regulations, there are essentially two separate natural gas market prices. The first can be referred to as the wellhead price, or the price that production and processing companies charge for large direct consumers within industry or manufacturing sectors. This price, as well as the processing and transmission of natural gas is regulated by the central government under the auspices of the National Energy Agency. The second price, referred to as the "city gate price" is the price that the national oil companies charge to the regional distributors for the natural gas that they either produce themselves, or import via pipeline to the consuming province.[99] These prices were also regulated, but under the authority of China's National Development and Reform Commission (NDRC) and were only occasionally adjusted to more closely match international gas prices.[100] From there, the provincial government would take over regulation and pricing responsibilities to set the cost for residential and small consumer usage within the individual province.

As a result of these differences between the cost to purchase natural gas on the global market and import it into the provinces where it is then sold at often artificially depressed city gate prices, the National Oil Companies have suffered substantial economic losses.[101] While these losses are naturally covered by the central government through subsidies and lump-sum payments, it has served to dis-incentivize large-scale investment in both domestic and import infrastructure of natural gas. This has led to the slower than expected increases in China's adoption of natural gas as a coal substitute.

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[98] Paltsev and Zhang, 43–56.

[99] Qin et al., "Challenges of Using Natural Gas as a Carbon Mitigation Option in China," 459–461

[100] Paltsev and Zhang, "Natural Gas Pricing Reform in China," 43–56.

[101] Qin et al., "Challenges of Using Natural Gas as a Carbon Mitigation Option in China," 459–461.

D. NECESSARY CHANGES

Even as a transitionary measure, China needs to make two significant changes in order for natural gas to effectively supplant coal as the primary means of energy production, both on the national and provincial level. The first change needs to be within the natural gas market itself in order to solve the price dilemma that keeps city gate prices artificially low for consumers (but still higher than coal) while at the same time discouraging companies from further developing infrastructure and innovating for more efficient methods. If the National Energy Agency wants to truly solve the natural gas price dilemma, they first need to create incentives for cost reductions within the production and distribution chain by encouraging further investment to enter the market, thereby increasing competition.[102] It is easy to see from Figure 1 that coal remains significantly more appealing from an economic perspective, at least to consumers, so the primary push if China wants to adopt natural gas throughout the country is to open up access in a competitive market and thereby drive cost down relative to coal.

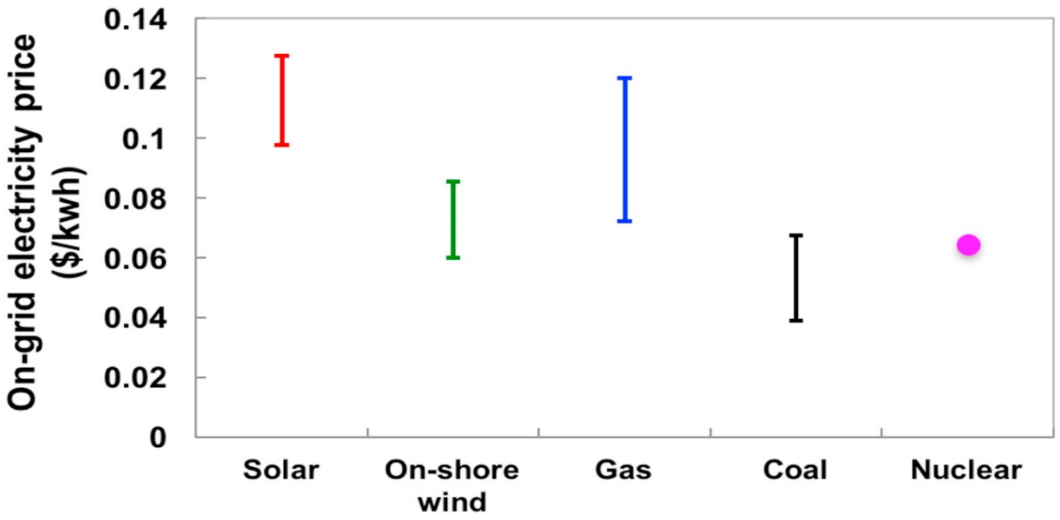

Figure 1. NDRC Record of China's Grid Price for Energy for 2017[103]

[102] Qin et al., 459–461.

[103] Source: Qin et al., 460.

The second change that the central government needs to push is directly tied into the cost of natural gas. A number of recent studies have shown that one of the most significant factors impacting natural gas retail prices is the high cost of transporting it and the associated access fees from the provincial and local distribution networks.[104] If the goal is to decrease the end-use price of natural gas relative to coal, then China needs to take steps towards a more competitive distribution network. The goal of which would be that "gas suppliers can directly negotiate contracts with local natural gas distribution companies and large consumers without the intervention of provincial gas distribution companies. Such open gas distribution pipelines can significantly reduce end-use natural gas prices as a result of lower distribution costs."[105]

Over the last few years, China has actually taken a number of steps in the direction of increased competition for the natural gas sector, but they have been largely half-measures: "For instance, two rounds of shale gas auctions were held to increase competition in natural gas production markets. However, the auctions were only open to domestic state-owned enterprises and selected private companies."[106] In addition, China is dealing with a lack of private industry technical expertise when it comes to natural gas production and deep shale development that tends to limit the participation of anyone other than the three primary national oil companies.

E. CONCLUSIONS

As a means of ensuring its ongoing Energy Security and environmental goals, China will be increasing both its import of, and domestic development of natural gas resources. China's short to mid-term goal is the phasing out of coal as the primary means of energy generation in the country. In order to do this, a clean, abundant source was needed that could supply the necessary fuel until future development of renewable sources could meet capacity requirements. For natural gas to be this viable stop-measure, China needs to

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[104] Cuixia Gao et al., "Interprovincial Transfer of Embodied Primary Energy in China: A Complex Network Approach," *Applied Energy* 215 (April 1, 2018): 792–807, https://doi.org/10.1016/j.apenergy.2018.02.075.

[105] Qin et al., "Challenges of Using Natural Gas as a Carbon Mitigation Option in China," 458–461.

[106] Qin et al., 458–459

make the necessary policy changes to make it cost effective and enticing to new investment. There are two main challenges that must be overcome before the price of natural gas is seen as a competitive replacement. The first is that the methods of extraction require significant amounts of water that are often located far from the resource deposits. In order to overcome this limitation, the pipeline infrastructure must be developed, preferably with central government funding incentives. The second challenge is simply that coal usage is so widespread, and all of the public infrastructure is already in place. This creates a step curve that a replacement energy source must overcome. The will to complete this shift will have to sustain the implementation phase of natural gas replacement until prices become comparable. One final change that China should consider if it truly wants to encourage the rapid adoption of natural gas over coal is to conduct a complete reform of the resource tax and fee system. Increases of natural gas as a percentage of total energy usage will continue rising gradually, but if it wants a rapid change, coal needs to be taxed at a much higher rate, and additional incentives need to be offered for new infrastructure development.

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IV. ENSURING A STEADY OIL SUPPLY

While undergoing this transition to renewable energy, one of China's most persistent and increasing needs is for a steady supply of oil imports. Previous chapters have focused on the domestic changes that have been occurring, but this chapter will shift to examine the international steps that China has taken to establish relationships with oil producing nations and secure sufficient oil imports to cover ever-increasing demands. According to the International Energy Agency, China's total energy generation capacity grew from less than 300 GW in 2000 to almost 1900 GW in 2017. In addition, the annual average growth of passenger car fuel use was almost 150,000 barrels per day over the same period.[107] As a general principle, countries look for energy sources that best provide for three core needs: economic security, geopolitical security, and environmental security.[108] In pursuit of these needs, China has made certain economic and political decisions that affect its relationships with countries around the world.

The primary goal of this chapter is to explore the role of foreign oil suppliers within China's current and future energy framework. In particular, this chapter will seek to answer the question: In what ways have China's growing energy needs in the form of oil and natural gas shaped its relationships with supplier countries over the last decade? In order to do so, this chapter will focus on the Middle East, Africa, and Russia as the three main regions/actors that have played a prominent role in meeting China's needs. This chapter will also examine the ways in which China's actions have affected the global energy market and what impact these changes have had on China's relationships with both suppliers and rival oil consuming nations. The main finding in this chapter is that China's pursuit of energy resources through bilateral trade deals has evolved over the last decade into a framework of regional infrastructure projects linked together through these bilateral deals that ultimately creates a more secure acquisition and transport network for China's ever-increasing energy import needs.

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[107] International Energy Agency, "World Energy Outlook 2017: China."

[108] International Energy Agency.

A. AN INCREASING NEED FOR OIL

Although China is home to Asia's largest reserves of oil and natural gas, domestic output cannot keep up with ever-increasing demand. As a result of this shortfall, China has been forced to drastically increase its reliance on oil imports. In 2002, the country imported roughly 2 million barrels of crude per day, and by 2016, that number had climbed to almost 10 million barrels per day, much of it coming from new agreements in the Middle East and Africa.[109] The predicted role of oil within China's sustainable energy goals remains largely unchanged. Over the next few decades, until electric cars become the new norm, oil will still be required for transportation and the movement of goods overland. China's efforts to create a more diverse portfolio for its sources of imported oil have met with some success, but the country is still reliant on a relatively small number of oil producing nations for more than 60% of its required oil imports (Russia, Saudi Arabia, Iraq, Iran, Angola, and Oman).[110]

In the past decade, China has made significant efforts to reach lasting, mutually beneficial agreements with countries throughout Asia, the Middle East, and Africa, all in pursuit of meeting its rising demand for oil and natural gas. The International Energy Agency defines energy security as the "uninterrupted availability of energy sources at an affordable price."[111] China's energy policy statements from the 12th and 13th Five Year Plans have made it clear that it is not yet confident in either the availability of, or the market price resilience of its previous energy suppliers. This has led to a number of wide sweeping efforts, both domestic and international, to continue creating a comprehensive energy security plan.

In order to feed the rapid growth of its economy and the ever-increasing consumption of energy, China has become increasingly dependent on natural gas and crude oil imports. Since it is able to supply the majority of its own domestic coal needs, China's

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[109] Erica Downs, "Russia Not Saudi Arabia Is China's Main Source of Oil," *Asia Dialogue* (blog), March 28, 2018, http://theasiadialogue.com/2018/03/28/the-new-king-of-chinas-crude-oil-imports-russia-and-the-competition-for-market-share-in-china/.

[110] Zha and Meidan, "China and the Middle East in a New Energy Landscape," 2–3.

[111] International Energy Agency, "Energy Security."

pursuit of oil and gas has resulted in a growth of trade relationships with energy exporting countries around the world.[112] Seeking to secure a diverse supply network, China's National Oil Companies have made significant equity investments in more than forty different countries.[113] In doing so, they have also served to create stronger diplomatic ties with potential allies and have begun to create regional energy related forums like the Shanghai Cooperation Organization in order to strengthen ties and smooth negotiations among member nations.[114] This reliance on foreign resources, while effective at meeting current demands, has some clear vulnerabilities that China is seeking to correct.

B. A NETWORK OF BILATERAL OIL DEALS

Over the last decade, China's efforts to ensure energy security have revolved around a series of bilateral trade and investment agreements with key oil producing nations that can appear as a form of energy diplomacy. Led by China's National Oil Companies and Sovereign Wealth Funds, Kang Wu (2014) determined that these institutions have pursued an aggressive overseas campaign designed to:

1. Leverage on the Chinese government's growing concerns over energy security.
2. Diversify sources of energy supplies and seek international profits to offset any potential losses in the domestic market.
3. Expand to maintain competitiveness in domestic market and enhance global competitiveness.
4. Tap on the vast pool of energy resources in the international market including both conventional assets and unconventional assets.
5. Develop new technologies and capabilities through joint development projects with other NOCs and international oil companies.[115]

For the purposes of this thesis, China's agreements with oil producing nations over the last two decades can be divided up into two distinct periods marked by a subtle shift in

[112] Cao and Bluth, "Challenges and Countermeasures of China's Energy Security," 382–386.

[113] Wu, "China′s Energy Security," 5–10.

[114] Odgaard and Delman, "China′s Energy Security and Its Challenges towards 2035," 108–114.

[115] Wu, "China′s Energy Security," 5–10.

policy. The first period, from the late 1990s through the end of 2012, can be viewed as a series of bilateral agreements with oil and natural resource producing countries that were structured around resource extraction and the ready availability of credit loans for infrastructure development. Countries like Angola, South Sudan, Venezuela, Iran, and the Republic of Congo are representative of this period and all have agreements with Chinese banks and resource development companies that have provided significant financial and development packages in exchange for a consistent flow of raw minerals and gas into China. These arrangements were most often described as package deals. They typically had three components. The first was the client state's Ministry of Finance which would be receiving the money. The second and third players in these deals are the companies that facilitate the transaction, the first of which is the extraction and exporting company, often the borrower's national oil company. On the Chinese side is the company responsible for importing the resources and often supplying the equipment or manpower necessary for the actual extraction labor. All of this would also be overseen by the ministry responsible for commissioning the deal and providing the funds back in Beijing.[116]

The second period of China's "energy diplomacy" is differentiated not by a shift away from these bilateral deals, but by a refocusing on infrastructure development and the means of transporting these resources.[117] The creation of larger, more wide-ranging efforts like the One Belt, One Road Initiative serve as a comprehensive means of creating secure infrastructure systems for the transmission of energy resources throughout Asia, Africa, and beyond. While still focused on bilateral energy trade deals with partner nations, China is also focused on creating more robust commercial links that tie the region together under a Chinese infrastructure and security umbrella.

Despite long-term goals to eventually move away from fossil fuels outlined in the 12th and 13th Five Year Plans, China had already established itself as the largest oil importer in the world by 2013. This status shows no signs of changing any time soon, and China's

[116] Deborah Bräutigam and Kevin Gallagher, "Bartering Globalization: China's Commodity-Backed Finance in Africa and Latin America," *Global Policy* 5 (June 1, 2014): 346–352, https://doi.org/10.1111/1758-5899.12138.

[117] Zha and Meidan, "China and the Middle East in a New Energy Landscape," 4–8.

need for oil is only expected to increase over the next two decades. This results in a situation where China's current supplies of oil imports are currently reliable and unchallenged, but central planners are uncertain about the future. In order to meet these demands of the future, China is seeking a deeper level of integration with the international community and global energy markets.

C. THE MIDDLE EAST AND SECURITY DILEMMAS

While making significant inroads and investment agreements with oil producers in both South America and Africa, the vast majority of China's oil imports still come from the Middle East. Prior to the BRI in 2013, the China-Middle East relationship was viewed as relatively modest, operating largely within the "oil for trade" framework: "In recent years the economic relationships have thickened, including finance and investment to compliment the increasingly robust trade component, and not surprisingly, interests have consequently become more complex."118 Chinese leaders are more and more frequently viewing the Middle East and East Africa as a strategically important region, while Middle Eastern leaders are increasingly looking east when contemplating long-term trade and development goals.

One of the most significant shifts in Middle East-China relations came about after the United States invasion of Iraq and the subsequent withdrawal of forces. Based largely on encouragement from the central government, China's national oil companies quickly positioned themselves to offer large sums of money all around the country to help rebuild and create new infrastructure projects: "In 2008 China's National Petroleum Company (CNPC) renegotiated a production-sharing contract to develop the al-Ahdab oilfield, which it had previously entered into with the Iraqi government during the Saddam Hussein era. The new technical service agreement granted development rights to CNPC for 23 years."[119] The following year though, CNPC along with Great Britain's British Petroleum (BP) formed a partnership with the goal of developing the Rumaila oil field. Having won the bid

[118] Jonathan Fulton, "China's Presence in the Middle East: The Implications of the One Belt, One Road Initiative/The Red Star and the Crescent: China and the Middle East," *The Middle East Journal; Washington* 72, no. 2 (Spring 2018): 341–343.

[119] Zha and Meidan, "China and the Middle East in a New Energy Landscape," 8.

to take over operation, this group was rapidly able to increase production output from less than 1 million barrels per day to more than 3 million barrels per day.[120] Around the same time, CNPC also entered into a partnership with France's Total Petroleum, and Petronas, Malaysia's state-owned oil company. The purpose of this joint venture was to take over development of the highly productive Halfaya field.[121] These joint ventures with European companies were only the beginning of China's investment in the country. Having gotten a foot in door with resource extraction, China's National Oil Companies were able to convince the newly formed Iraq government to accept loans and investment money in many other projects that would bring both countries closer together.

In spite of international sanctions against them, Iran remains one of China's most valuable trading partners in the region. In 2017, the value of goods traded between China and Iran was in excess of $27 billion with over $9 billion of that in oil exports to China. This amounted to more than 633,000 barrels of crude on a daily basis and cemented China as Iran's largest oil customer.[122] Ties between China and Iran go well beyond just oil. In recent years, China has made significant investments in Iran's domestic infrastructure as well as oil refineries: "One key project is a $2.56 billion high-speed railroad from Tehran to the eastern city of Mashhad, with China providing a loan of $1.6 billion to fund the electrification of the 926-km railroad. That was the first foreign-backed project after Iran signed the nuclear deal with six major powers, including China. In July, state-owned China National Petroleum Corp took a 30% stake in a project to develop South Pars in Iran–the largest natural gas field in the world."[123] In January of 2017, Beijing also agreed to a $3 billion deal between Sinopec and the National Iranian Oil Company to refurbish and expand Iran's largest oil refinery.[124] This close cooperation is a key piece in China's pursuit

[120] Fulton, "China's Presence in the Middle East," 341–343.

[121] Zha and Meidan, "China and the Middle East in a New Energy Landscape," 7–9.

[122] "Iran Exports to China Up 27% in First Three Quarters of 2017," Financial Tribune, November 19, 2017, https://financialtribune.com/articles/economy-business-and-markets/76415/iran-exports-to-china-up-27-in-first-three-quarters-of.

[123] "Iran Exports to China Up 27% in First Three Quarters of 2017."

[124] "Sinopec Signs $1b Abadan Refinery Expansion Deal," Financial Tribune, December 29, 2017, https://financialtribune.com/articles/energy/78896/sinopec-signs-1b-abadan-refinery-expansion-deal.

of a stable supply and a stable price for oil. As the world's 11th largest oil producer, Iran is ideally placed to fuel China's needs and it is likely this partnership will only continue to grow.

D. TRANSPORTATION SECURITY DILEMMA

Despite these stronger ties with oil producing countries in the Middle East, China has been confronted with a security dilemma. When faced with the task of getting all of that oil into the country, there are two primary means of transport, either by overland pipelines through western China, or by large shipping tankers. For the magnitude of oil coming from the Middle East and Africa, shipping tankers via water are by far the most cost effective and efficient method of crude transport, but it the context of energy security and comprehensive national security, this poses an additional level of risk.[125] While China has been relatively successful in diversifying the sources of its oil, most of its oil imports are delivered by sea in tankers via the Malacca Straits. The United States has kept up a strong fleet presence in these waters for the last two decades in an effort to support local multilateral freedom of navigation and safety of passage agreements through this transit lane: "This is perceived as a realistic security threat by China. On the one hand, Chinese ships travel under a security umbrella provided by the US, on the other hand the U.S. fleet could block China's oil supplies if a conflict arises between China and the US. Terrorism and piracy are also latent threats along this important sea transport route."[126] Even though the realistic likelihood of this ever happening is slim to none, Chinese policy makers still felt the need to limit this strategic vulnerability.

In an effort to build stronger economic relationships throughout Asia and limit strategic vulnerabilities like the perceived Malacca Dilemma, Xi Jinping's One Belt, One Road Initiative has sought to secure leases and build ports in the countries of Myanmar, Pakistan, Sri Lanka, and the Maldives. By building these ports, particularly in Pakistan and Myanmar, China is seeking to mitigate the effects of some hypothetical naval blockade since these two countries are also connected to China via newly developed overland

[125] O'Sullivan, *Windfall*; Economy and Levi, *By All Means Necessary*, 220–232.

[126] Odgaard and Delman, "China′s Energy Security and Its Challenges towards 2035," 109.

pipelines.[127] In the event of a maritime conflict that would potentially cut off access to the Straits of Malacca, China could concentrate its forward deployed assets within the Indian Ocean to protect tankers and these ports rather than spreading its forces along the entire route back to mainland China.[128]

More than that though, the One Belt, One Road initiative has been a way for China to promote its economic goals and transportation infrastructure agenda throughout Asia and the Middle East. The 13th FYP lays out a number of key objectives aimed to increase China's role in the ongoing formation of global economic norms. In particular, Beijing would like to see the adoption of the renminbi (RMB) as a global trade and reserve currency, and an increase in foreign investment opportunities for its capital. In order to achieve this second goal, China has sought to expand its trade opportunities through such economic frameworks as the Beijing-Tianjin-Hebei megaregion and the Yangtze Economic Belt.[129] These interregional frameworks would seek to extend China's influence in previously marginal markets and bring new resources into the country. This increased infrastructure development only strengthens China's ties with its energy producing neighbors and ensures a more stable environment for energy markets.

E. RELATIONSHIP WITH RUSSIA

A long time trading partner and supplier of both natural gas and oil, Russia provides an answer to China's worries of maritime chokepoints and vulnerable tanker ships. Beginning in 2016, Russia surpassed Saudi Arabia as the largest supplier of crude oil to China.[130] "China's imports of Russian crude oil have nearly quadrupled in less than a decade, increasing from 320,000 barrels per day (bpd) in 2010 to 1.2 million bpd in 2017. No other country ranked among China's top ten crude oil suppliers in 2017 experienced an

[127] Economy and Levi, *By All Means Necessary*, 47–61.

[128] Leung, "China's Energy Security," 1331–1334.

[129] Koleski, "The 13th Five-Year Plan."

[130] Downs, "Russia Not Saudi Arabia Is China's Main Source of Oil."

increase of comparable volume. Russia's deliveries to China topped 1 million bpd for the first time in 2016."[131]

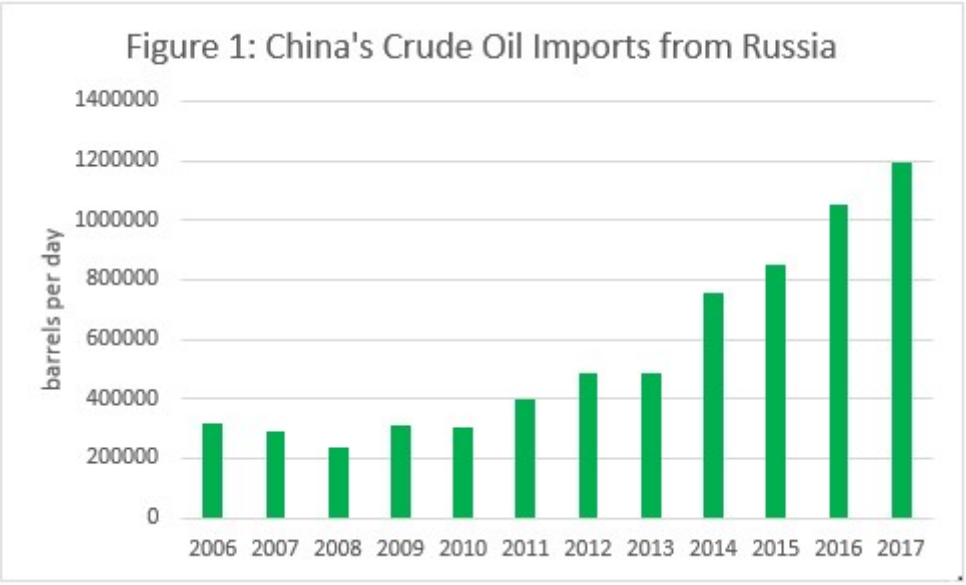

Figure 2. Dow Jones Chinese Customs Data.[132]

Key to the China-Russia oil relationship is the construction of transportation pipelines and long-term supply contracts. Completed in 2011, The East Siberia Pacific Ocean (ESPO) pipeline consists of two parallel pipelines running from Russia on to Daqing. Together these two pipelines are capable of delivering more than 600,000 barrels per day.[133] This is in addition to the existing series of pipelines that have been transporting natural gas and crude oil for over 20 years. As far as long-term contracts go, in 2009, the ongoing global financial crisis resulted in a sharp drop in the price of oil. This in turn caused Russian oil companies Transneft and Rosneft to reach the point of defaulting on upcoming debt payments. In exchange for agreeing to ship more than 300,000 barrels per day of crude oil through the pipeline for the next 20 years, the China Development Bank

[131] Downs.

[132] Source: Downs.

[133] Downs.

offered these two companies a $25 billion line of credit.[134] "In 2013, Rosneft once again sought capital from China to ease its debt burden, which grew considerably after its purchase of Russian producer TNK-BP for $55 billion. Rosneft agreed to send China an additional 300,000 bpd for 25 years in exchange for prepayment for a portion of the oil, which was valued at $270 billion based on the price of oil at that time."[135] This history of joint infrastructure development and investment is likely to continue for much of the next century and Russia will remain one of China's key pieces in an expanding network of stable crude oil and natural gas suppliers.

F. RELATIONSHIP WITH AFRICA

After the Middle East, China's second-largest source for crude oil imports is Africa, from which it receives more than 1.4 million barrels per day, or 22% of total.[136] For years, the Chinese National Oil Companies have pumped billions into resource development and exploitation contracts throughout the continent, deepening economic ties and providing China as a new market for its manufactured goods.[137] By 2009, China's involvement in the continent had grown to such a degree that it had passed the United States to become Africa's largest trading partner. The relationship is not one sided either. "China is the destination for 16% of sub-Saharan Africa's exports and the source of almost 20% of the region's imports,"[138] according to estimates from Thomson Reuters and the World Bank. The vast majority of goods that China imports from Africa come in the form of raw goods which are then turned into finished goods that are then sold back. Much of China's interest in Africa comes in the form of mineral rights, fuel extraction and raw metal ores. Africa in turn requires the machinery, vehicles, and telecommunications technology that China can produce cheaply enough to appeal to these markets.

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[134] Downs.

[135] Downs.

[136] "China in Africa," Council on Foreign Relations, accessed June 17, 2018, https://www.cfr.org/backgrounder/china-africa.

[137] Muller-Kraenner, *Energy Security*, 67–75.

[138] "China in Africa."

The model for Chinese investment in these developing countries typically has two main aspects: strategic development partnerships with Chinese companies, and commodity-secured finance deals. In their paper examining China's commodity backed finance practices, authors Deborah Brautigam and Kevin Gallagher explain that for the first strategic partnership aspect, Chinese banks typically "would require a letter of application from the Minister of Finance of the borrowing country, an engineering, procurement and construction (EPC) contract with a well-regarded Chinese firm, a project feasibility study and an environmental impact assessment report. The Chinese importer would only then sign a purchase agreement with the company selling the commodity."[139] In addition, these agreements often stipulated that Chinese labor forces would be required to participate in the project.

In 2015, Chinese President Xi Jinping pledged that China would invest an additional $60 billion in infrastructure and development projects around the continent, as well as an additional $100 million in military aid to the African union.[140] As part of the "great build-out," China is willing to use its large capital reserves and is eager to maintain relationships with these nations and shift its labor- and energy-intensive industries to Africa to broaden its partnerships beyond energy.[141] As a result of this renewed commitment to the continent, China has begun sending troops to participate in U.N peacekeeping operations as well as creating a permanent military base in Djibouti. "By March 2017, more than 2,500 Chinese troops, police, and military experts have been dispatched to six UN peacekeeping missions in Africa, four of which are in Darfur, DRC, Mali, and South Sudan; there are also smaller contingents in the Ivory Coast and Western Sahara."[142]

These goodwill efforts are becoming more and more necessary. As China continues making deals and providing investment in exchange for critical resources, the local populace is naturally going to end up feeling exploited and advocate for change. In effect,

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[139] Bräutigam and Gallagher, "Bartering Globalization," 346–352.

[140] "China in Africa."

[141] O'Sullivan, *Windfall*, 214–221.

[142] "China in Africa."

China has had to work hard to avoid the image of a new colonial power. "In 2011, Michael Sata won Zambia's presidency in part by tapping into anti-Chinese sentiment after Chinese managers shot protesters at a large coal mine in southern Zambia. In 2013, Sanusi Lamido Sanusi, then-governor of Nigeria's Central Bank, wrote 'we must see China for what it is: a competitor.'"[143]

G. POSSIBLE CONCERNS

China's economic largess does not come without its own share of risk though. In a March 2018 report from the Center for Global Development, the authors argue that in its pursuit of favorable trade and resource extraction deals with lesser developed countries, China's practices of excessive lending and financial aid to developing countries actually poses serious risk. The specific case studies mentioned were Mongolia, Laos, Tajikistan, Kyrgyzstan, Djibouti, Montenegro, and the Maldives.[144] Since China is not a member of the OECD, it is not bound by any limitations in how much they lend to developing nations. If a country takes a loan that they are unable to pay back, China is in a position to graciously take certain high value or strategic assets as collateral in exchange. These ports, mineral rights, or power transfer infrastructure development projects have a value that is far greater to China than the simple monetary value of the loan.[145]

China's increased leveraging of economic cooperation for its energy security could also be translated into actual physical or military power in the future: "The infrastructure being built by China, including roads, railways and ports, will not only contribute to economic development in the region, it will also help to improve connectivity throughout Eurasia. At the same time though, that infrastructure will benefit China's military, enabling Beijing to secure an effective means for communication and the movement of troops in a

[143] "China in Africa."

[144] John Hurley, Scott Morris, and Gailyn Portelance, "Examining the Debt Implications of the Belt and Road Initiative from a Policy Perspective" (Center for Global Development, March 2018).

[145] Shin Kawashima, "The Risks of One Belt, One Road for China's Neighbors," The Diplomat, accessed June 18, 2018, https://thediplomat.com/2018/04/the-risks-of-one-belt-one-road-for-chinas-neighbors/.

contingency."[146] With China's development of a military base in Djibouti and the increased deployment tempo of its naval forces in the Middle East, the possibility now exists that China could use these new resources for military action rather than just peacekeeping operations.

H. CONCLUSIONS

The last decade has witnessed a transition in Chinese policy from bilateral resource exploitation agreements with individual suppliers to a comprehensive energy infrastructure development policy focused on securing key resources. Tools like the One Belt, One Road initiative, have allowed China to consolidate its efforts in multiple bilateral arrangements under one large umbrella. This consolidation of effort while clearly building up China's ability to secure stable supplies and prices for its energy imports has also had the larger impact of placing China as the regional leader for infrastructure development throughout Asia, The Middle East, and Africa. In doing so, China has used its banks and national oil companies to conduct a new form of energy diplomacy in which Chinese influence is now unavoidable in much of the world. China's continued growth over the next few decades is only going to increase its appetite for energy, and consequently, its dependence on foreign suppliers. Much like the United States, China's energy policy is focused on increasing supply, rather than on reducing demand through conservation or alternative technologies.[147] Granted, China is seeking to become a leader in clean energy technologies, but for the foreseeable future, Oil, Natural Gas, and Coal are going to be the cornerstone of China's economic and industrial framework. In order to keep up consistent rates of growth, China will likely continue to create economic and political bonds with both the Middle East, Asia, and Africa, both as a means of obtaining resources, but also as a means of exporting Chinese influence.

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[146] Kawashima.

[147] Charles Ziegler, "The Energy Factor in China's Foreign Policy," *Journal of Chinese Political Science* 11 (March 1, 2006): 1–23, https://doi.org/10.1007/BF02877031.

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V. CONCLUSION

The primary goal of this thesis was to examine the dramatic changes that China has undertaken in the last decade to begin the transition away from a primarily coal-based, heavy manufacturing energy framework. It also wanted to determine what if any policy or market-based changes still needed to occur in order to reach the central government's 2030 goals for renewable energy development. The steps that China has taken in the last decade have been a direct result of the acknowledgement of the health and environmental costs of reliance on coal and other fossil fuels to drive sustained growth. In order for China to reach its goal of having renewable energy sources supplant coal as the dominant national power provider by 2030, the central government has set specific policy goals for local and regional implementation. These policies are paired with national investment initiatives and market reforms aimed to spur additional private investment into renewable power infrastructure projects as a part of reorienting the national grid system. The goal of this additional investment is to overcome to initial hurdles of getting power from the generation sources to the large population centers on the coast and reduce the cost of doing so in order to reach a cost parity between renewable energy and coal.

Rather than wait for renewable generation capacity to ramp up to sufficient coal replacement levels, China has taken steps to phase out coal usage in favor of natural gas as a short-term stopgap measure. This shift to a significantly cleaner-burning fuel source will have immediate advantages in terms of smog in urban centers and the associated health costs. The problem that China faces with this replacement though is the need to import significantly more natural gas than the country is capable of producing. This is causing the central government to reconsider the way it addresses both domestic market incentives for natural gas production, and natural gas pricing mechanisms at both the national and local level. Faced with many of the same cost issues as renewable energy, the government is working to bring down the cost of natural gas relative to coal in order to make this replacement initiative more widely accepted. The cost comparison is the driving factor in determining how quickly China can phase out coal usage. As transportation and infrastructure expenses are currently far higher than coal in this early implementation

phase, prices are naturally higher, but will continue to fall over the next decade, to the point where coal is no longer the clearly cheaper option.

The role of oil within China's energy system will remain largely unchanged during this transition. What will change though is China's relationships with oil producing countries and the growing number of bilateral development deals to ensure a steady, uninterrupted supply. Unable to meet its growing demand, China has to look outwards and has chosen to use its national oil companies to conduct financial diplomacy through investment projects and joint resource extraction agreements through the Middle East and Africa. This widespread network has provided a degree of security through diversity as China is not reliant on any single supplier to meet its needs, thus largely insulating itself from market volatility and fluctuations in supply.

These three aspects of a comprehensive energy framework paint a picture of a country that has a clear vision for what it wants to achieve, and is taking measures to ensure that happens sooner rather than later. When it comes to health and the environment, it is not really up for debate any longer that renewable energy is the future, and countries that seek to develop both the technology and infrastructure earlier are going to be better situated in the long run. This is one area in which the United States needs to take note and make its own gradual policy changes regarding renewable energy adoption before a more abrupt and painful shift becomes necessary in the future.

Having only explored the three primary ways in which China is going about securing its energy needs over the next few decades, there are still a few aspects of China's energy outlook that have been left unaddressed but are still worth noting. The first is the role of nuclear power in a country that up until 2011 was the world's largest developer of new nuclear capacity. What are China's plans for nuclear power as a percentage of total output over the next few decades? The second issue that should be addressed has less to do with China and more with the possibility of future competition for energy resources between the two largest economies in the world. Namely, how do energy forecasts look for China compared to the United States? Will these two countries find themselves courting the same producers of oil and natural gas, or is the development of domestic sources and proposed renewable generation sufficient to meet projected needs. What is the possibility

to future cooperation between these two powers, both in terms of technology sharing, and trade? The point of this thesis was not to compare China's energy development to that of the United States, but such a comparison still begs at least a cursory examination.

A. NUCLEAR POWER IN DECLINE

When considering that three of the four nuclear reactors brought online worldwide last year were in China, the failure to dedicate a significant portion of this thesis to nuclear power may seem like a strange omission, but one must consider the larger picture. China has the capacity to produce around 10 nuclear reactors a year, but despite increasing need for power and the previously mentioned shift away from coal usage, there has been a halt on all new nuclear power projects since 2016.[148] China is facing two separate issues when it comes to nuclear power generation. The first is that relative to other power sources, even wind and solar, the cost of building new nuclear power plants is simply too expensive. The second is that following the 2011 reactor meltdown in Japan's Fukushima plant, public opinion of nuclear power's safety has sharply declined. In 2017, China's National Energy Administration conducted a survey that found less than 40% of the public was supportive of continued nuclear power development.[149]

To address the first issue of cost, new reactors constructed with enhanced cooling systems and modified safety features designed to stop a disaster similar to that in Fukushima are significantly more expensive to create than existing plants. At the same time, production of renewable power sources continues to improve, driving relative cost disparity down. When faced with risk calculation of starting a controversial new nuclear power plant project or investing in additional wind and solar power, China's choice over the last few years has almost entirely turned away from nuclear power as a viable option.[150]

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[148] Peter Fairley, "China's Losing Its Taste for Nuclear Power. That's Bad News.," MIT Technology Review, accessed March 3, 2019, https://www.technologyreview.com/s/612564/chinas-losing-its-taste-for-nuclear-power-thats-bad-news/.

[149] Fairley.

[150] "New Energy Outlook 2018," Bloomberg NEF, accessed February 2, 2019, https://about.bnef.com/new-energy-outlook/.

As for the second issue of public perception regarding nuclear power, two days following the Fukushima disaster, all construction of nuclear projects was put on hold. When the projects started back up months later, the new laundry list of additional safety features and required inspections added significant cost overruns and time to each project going forward. Despite these additional safety features though, the negative impact to public perception was already complete. Following a number of very public protests around proposed new power plants, notably in Jiangmen, and in Liangyungang, the central State Council modified its regulations to require public hearings prior to any new projects being started.[151]

This is not to say that nuclear power will not continue to be a part of the total energy production grid, but that it will just play a decreasing role going forward. The international Energy Agency predicts that by 2040, China's energy makeup will include only 4% of generation capacity from nuclear sources. Fifty-two percent is expected to come from solar, wind, and hydro power, 30% from residual coal powered production, and the remaining 14% from natural gas.[152] When faced with the twin challenges of increasing costs and negative public perception, China's policy makers have simply decided that nuclear power is not the way of the future and will limit any development of new nuclear projects going forward.

B. HOW DOES CHINA'S PURSUIT OF ENERGY SECURITY COMPARE TO THE UNITED STATES?

One of, if not the most significant takeaway from China's changing energy framework is the effort to become as self-sufficient as possible. Beyond the obvious health and environmental benefits, the single greatest impact that renewable energy will have on China is the fact that it will free the country from reliance on foreign imports of both oil and natural gas. While natural gas imports have been increasing in recent years at the same time that renewable energy development has been taking place, this growth has only been necessary to meet rising demand. Natural gas is helping to fill a transition point in China.

[151] Fairley, "China's Losing Its Taste for Nuclear Power. That's Bad News."

[152] International Energy Agency, "World Energy Outlook 2017: China."

The eventual goal as detailed in previous FYPs is to completely transition to an energy market that is both clean, and self-sustaining. To refer back to the International Energy Agency's definition of energy security as the "uninterrupted availability of energy sources at an affordable price,"[153] China is seeking to eliminate all chances of supply interruptions by producing all needed generation capacity domestically.

When compared to the United States, there is a similar trend of pursuing energy security through increased domestic generation capacity, but with a different perspective. This difference lies largely with the availability and accessibility of each country's resources and the relevant extraction technology. In particular, the shale oil boom in Texas has transformed the global oil market, resulting in the United States unseating Russia and Saudi Arabia to become the world's largest producer of crude oil for the first time since 1973. This increased output has played a large part in reducing the United States' reliance on foreign oil, and reducing the importance of OPEC nations in setting the global oil price. In the last few years, Texas' Permian Basin has produced enough oil to qualify as the third largest producer in the world, ahead of both Iraq and Iran. In fact, the supply of shale oil there is so large as to meet all of America's future needs for at least the next 450 years taking into account future growth.[154]

The problem though is that climate change is real, and continuing to rely on fossil fuels for energy is not a viable long-term plan. United States policy makers and lobbyists have taken steps to limit the growth of renewable energy by reducing tax incentives and placing tariffs on renewable energy technology imports, particularly from China. The ready supply of oil and natural gas in the United States has led to a false sense of complacency among policy makers resulting in a sense that there is no need to transition to renewable energy since the country has all of the fossil fuels it could need for the foreseeable future. This availability of domestic supply is the single largest difference between the United States and China, particularly when it comes to policy. The United States does not need to

[153] International Energy Agency, "Energy Security."

[154] O'Sullivan, *Windfall*, 218–231.

create the same network of suppliers to meet a growing demand, and is in fact banking on being a future supplier to much of the world.

C. FUTURE U.S.-CHINA COOPERATION

One of the most likely avenues of future bilateral energy cooperation with China will come in the form of liquid natural gas exports. Beginning in 2016 and persisting uninterrupted through the recent trade disputes, the United States started shipping LNG to China in the amount of almost 3 billion cubic meters per year. By 2019, the United States capacity to export LNG is expected to reach almost 100 billion cubic meters annually. Having already discussed China's goals of replacing significant amounts of coal power generation with natural gas over the coming years, the country's reliance on imports is only going to increase, and it is unlikely that traditional suppliers will be able to meet the new demand. According to Brooking's research, "In 2017, China's natural gas consumption increased by 15%, and its import grew by 28%. The country's import dependency climbed from zero in 2005 to 39% in 2017."[155] With the projected growth of natural gas as a percentage of total energy usage in China, by 2030 the annual consumption rate will reach roughly 650 billion cubic meters, almost three times that of the 2017 levels.[156]

Considering the unique difficulties associated with accessing its domestic shale gas deposits, China is going to have to find another means of making up the projected increased in natural gas demand over the coming decades. The majority of natural gas imports into China arrive via the overland pipelines from Turkmenistan and Russia, and are generally limited by pipeline capacity. As of 2017, LNG makes up the remaining 21% of China's total natural gas imports, with the majority coming from Australia, Qatar, and Malaysia.[157] The problem is that these suppliers are not capable of meeting future demand. These top three countries will be able to increase LNG production by about 15% by

[155] Lu Jiaqi and Qi Ye, "U.S. Gas to China: Positive Energy for Bilateral Relations," China's Energy in Transition (Brookings Institute, May 31, 2018), https://www.brookings.edu/2018/05/31/u-s-gas-to-china-positive-energy-for-bilateral-relations/.

[156] Jiaqi and Ye.

[157] Jiaqi and Ye.

2030,[158] but this is nowhere near the demand curve that China is going to be facing. This leaves the United States as the ideal candidate to fill the gap.

Rather than deal with the limitations of pipelines, the shipping import terminals are located near major industrial and urban centers along the coast and are paired with well established distribution networks. Compared to the cost of maintaining the overland pipeline infrastructure, the cost of importing natural gas from Turkmenistan to the coast is significantly more than that of importing U.S. LNG via tanker ship.[159] When faced with calls of unfair trade balances between the U.S. and China, increased Chinese LNG imports at a time when it would greatly benefit both countries seems like an ideal solution. Having greatly improved upon fracking and shale oil extraction technologies, cooperative agreements between the U.S. and China need not be limited to resource exchange. Joint development ventures using American fracking technology to improve access to China's untapped natural gas reserves is another possible avenue for increased cooperation between these two countries.

[158] International Energy Agency, "World Energy Outlook 2017: China."

[159] "China's Old Gas Allies Fail to Meet Demand Boom in Winter," February 25, 2018, https://www.bloomberg.com/news/articles/2018-02-25/china-s-traditional-gas-allies-fail-to-meet-winter-demand-boom.

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